INDUSTRY EXPECTATIONS OF SCIENCE AND PROBLEMS IN ITS MANAGEMENT

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Let me start by specifying the industries to which my comments are relevant and outlining the areas I intend to cover. The industries are the primary and secondary industries, and tertiary industries such as transport and communications which service the other two in the production of wealth. I am aware the economists would include other tertiary industries such as banking, retailing, tourism, entertainment, etc. but I see these as either facilitative of the basic "wealth producers" or of only secondary importance. I include scientific research and the generation of knowledge as wealth producing—if the results are exploited.

I shall treat science as "the systematic organisation of knowledge" and "scientific research" as the application of a particular intellectual process to the generation of new knowledge. It is important to draw the distinction between the scientist trained to generate and organise knowledge and the technologist (for example, the engineer) who is trained to apply knowledge to solve particular problems.

In looking at the expectations industry has of science I shall look at the situation within a particular industry or enterprise and at what industry can reasonably expect of the wider scientific community—including the university. I shall examine some of the problems encountered in making effective use of science, and suggest some solutions.

SCIENCE WITHIN AN INDUSTRY OR ENTERPRISE

Industry employs scientists because it needs their knowledge of a particular discipline, and their trained mind. It looks to science to solve its current problems and, in today's world, to create its new products and businesses. To make an effective contribution to meeting these needs the scientist must have the following attitude:

- imagination, creativity and an ability to spot opportunities;
- an appreciation of the methods of business and the constraints within which it operates;
- an ability to apply science to a wide range of problems; and,
- a knowledge of the process and the barriers to be overcome in bringing a new innovation from conception to profit making.

Time will not permit me to develop the methods of business and the constraints within which it operates in any detail but it is important we understand the essential features. They are:

- all business operates to satisfy a need;
- the enterprise operates in an environment in which it must compete or cease to exist;
- it must generate a satisfactory return on the assets employed; and,
- many constraints are imposed on it by government and by the community at large, e.g., the Trade Practice Acts, occupational health and safety regulations, product liability, etc.

The effective utilisation of science requires skilful and specialist management which must understand science and scientists and the process of translating new knowledge into profits. To use John Onto's definition, the role of that management is:

> "*Planning, organising, directing and controlling the activities of the scientist to achieve the desired goal of the enterprise.*"

The first and hardest task in managing science in an enterprise is to identify scientific goals which are consonant with and will support the overall goals of the enterprise. This may be relatively easy where a scientific team is engaged on process trouble shooting or product improvement but requires considerable vision, imagination, creativeness and an ability to persuade and convince sceptical colleagues or perhaps unimaginative bankers where the work may lead to new products or businesses or render an existing product line or business obsolete.

The second task of the manager of science is to create and maintain the environment in which the scientist can carry out this work. He must be free of the day-to-day distractions of business and have the resources needed for his task but also kept up to date within the goals of the enterprise, developments in the industry, company and government policies, etc.

Finally the manager has to monitor the progress of the scientist's work and make the hard decisions on when a project should be transferred from research to implementation, when it should be terminated or when a whole field of science or research should be abandoned. It is relatively easy to start a research project; it is far harder to kill it. To do so the research manager has to contend with not only the commitment and enthusiasm of the scientific team and their conviction that success is just around the corner, but also with the fact that he may have already spent large sums on the project which will be wasted if it is not successful, the worry that the scientists may be right and success *is* just around the corner, also with the problem that if he does abandon the work he may be left with people he can't employ elsewhere. Successful decision making in this area requires the early and careful definition of the problems to be solved, the setting of progressive goals and the very careful monitoring of progress towards them. If the "problem gap" is not closing, alternative scientific strategies must be devised or the project abandoned.

It is also essential that the scientist and the manager constantly review the relevance of the project to the goals of the enterprise. Very often the manager must rely on the scientist to recognise and advise him of new developments which may make the project redundant, e.g., recognition of the significance of early publications on solid-state electronics made continued work on the vacuum tube irrelevant. Similarly the manager must also look to the market place—there may be no justification for continuing work on a project if the competition has reduced prices below a level at which the costs of further research and development could be recovered.

In employing scientists, industry also hopes that, at a later stage, the intellectual disciplines and training in problem solving which the scientist has received will allow him to make an important contribution to the management and later the direction of the enterprise. John Onto has offered us two hypotheses on the effectiveness of technologists in management. They are:

Hypothesis 1

That technologists are ill equipped by virtue of their training, values and other personality characteristics for the role of management.

Hypothesis 2

That the role of management, in the technological context, is in, and of itself, a precondition for failure in the job.

May I say that I support the first in full and stress than it applies even more strongly to the scientist than it does to the technologist or engineer. You will see I have reservations about the second. The scientist is trained to think divergently, to generate new ideas and new knowledge and not to accept constraints or convention; the technologist is trained to apply knowledge to the solution of defined problems. That training has already introduced him to some of the pragmatism needed in management. John Onto also referred to the significance of the differing personality traits, educational experiences and value systems of the scientist and the manager and to Balderston's very useful analysis of their role differences which, if may I remind you, are shown in Table 1.

Whilst the scientist or technologist is trained (probably from the mid teens) to handle data and to solve well defined problems (and probably selected these areas because they felt more comfortable dealing with the concepts, quantifiable data, and defined problems of the maths, physics and chemistry than those with the human relations, communication skills and ill-defined problems encountered in the humanities), the problems encountered by the managers and directors of an enterprise are more often than not nebulous, ill-defined, unstructured and have no finite solution; skill in communication is often paramount. Thus the effective utilisation of scientists and technologists in management require not only the identification of those individuals who can make the transition to the management role but training in the skills involved.

The organisation must also ensure that the "Peter Principle" does not operate. That is, it must avoid promoting its best scientist to become an incompetent manager. As the hierarchy and reward structures of business are usually tied to the management structure the successful exploitation of science in industry must also offer a "career ladder" along which the scientist or technologist can progress and gain recognition. Whilst this can parallel the management ladder it is often difficult to cover the full range or to provide the same level of recognition available in the academic world. It can often be helpful to both industry and academia when a relatively free interchange of personnel between the sectors can be achieved.

INDUSTRIES EXPECTATIONS OF THE WIDER SCIENTIFIC COMMUNITY

Whilst industry expects to carry out the applied research needed for its development, it looks to the academic world and the wider research community for both the scientists trained to do that work and for the basic research needed for the generation of new knowledge, new enterprises and new sources of wealth.

Table 1
Management and Technical Specialist—Some Role Differences

Management	Technical Specialist
Counsels, guides, directs people	Is consulted by people
Is sensitive to feelings, attitudes	Is intuitive, creative
Evaluates people's performance	Evaluates data systems or methods
Forecasts, analyses, controls costs	Technical performance outranks cost
High verbal skill required	High analytical skill required
Transmits and enforces policy	Logic outranks conformity
Directs what methods to use	Determines operational methods
Makes decisions from insufficient data	Seeks additional data
Accepts organisational hierarchy	Accepts hierarchy of truth
Seeks relationships to business goals	Seeks relationships among technical facts

Australia's tertiary education system has its roots in the British model and, I believe, that many of our academic research establishments were founded on the 19th century precepts of Oxford and Cambridge. Those precepts were that university research must seek knowledge solely for knowledge sake and that their researchers should be untrammelled by any association with trade or industry. It is worth remembering that the physical sciences were only recognised by Oxford and Cambridge many years after they were well established as disciplines in the German universities and at the Sorbonne and that in both Germany and France academia had, by then, established a close working relationship with industry.

A consequence of that attitude is that even today little attempt is made in English universities to protect intellectual property and that most of the new knowledge they generate is exploited elsewhere. The same has been the tradition and experience in Australia. The Oxbridge attitude is far removed from that at some U.S. universities—notably Stanford, Harvard and M.I.T. There the research scientist, whilst recognising that publication and the free communication of new knowledge is essential to the progress of science, seeks to protect the intellectual property therein and to exploit it for the benefit of their community and themselves. I believe that it is this difference in attitude which accounts for the so productive "science parks" in the Palo Alto, Silicon Valley and Cambridge areas of the U.S., and the absence of such developments in England. It also accounts for the international supremacy of the German chemical industry between say 1860 and 1945.

Whilst no one can question the success of Australian Universities in producing world class scientists and making a better than average contribution to the general growth of knowledge it is also true that only a small proportion of that work makes a direct contribution to the wealth of this nation. In today's highly competitive world in which basic research in other countries is either oriented to national goals, as in Japan and the eastern block, or serves communities with very large markets in which every strand of the work can be exploited through their traditional close relationship between academia and industry (U.S. and Europe), Australia can no longer afford the luxury of its present policies under which some 80% of our research is solely for the pursuit of knowledge and is unlikely to make any contribution to Australia's wealth. It is, I think, a reasonable expectation of industry and of the community at large, which carries the cost of such work, that more of the basic research carried out in our universities be directed towards areas in which there is, at least, some reasonable, long-term prospect that the knowledge generated will be exploited by an Australian industry.

It is also reasonable to expect that the system should produce scientists who actively seek opportunities to exploit the knowledge they generate rather than being satisfied with the kudos they receive from publication. The U.S. experience suggests that these goals of pursuit of knowledge—free exchange and publication and exploiting the results are not incompatible and that the change in attitude required may be relatively small.

I have argued that industry employs scientists because it needs their knowledge and trained minds and that it looks to them to solve its current problems and to create new businesses and new wealth. I suggest that the nation's needs are the same and that the only difference is in the time scale. Similarly I suggest that the process and problems of managing science on a national scale are basically the same as those encountered in industry. Each requires:

- The identification of relevant goals;
- The provision of a climate in which science can flourish;
- The monitoring of progress towards those goals and the adjustment of the work program to achieve them; and,
- The courage to terminate projects which are no longer relevant.

Again the differences lie in the time scale and the magnitude of the task but also in that industry recognises the need for management and attempts to tackle the task—the nation does not.

SUMMARY

Let me attempt to summarise:

- An enterprise, an industry and the nation all need science to survive in today's competitive world.
- To be worthwhile science must be oriented towards goals which support the overall goals of the enterprise or the nation.
- Science must be well managed and directed if these goals are to be achieved and resources used effectively.
- Scientific training predisposes a person *against* effectiveness in management.
- Scientists can, however, be very good managers if the deficiencies of their training are recognised and they are properly selected and trained for the job.

Thank you ladies and gentlemen for your attention and the opportunitiy to express these perhaps iconoclastic views.